

FLIGHT TEST PLAN TO ASSESS OF PVFR ROUTES AND SNI OPERATIONS FOR ROTORCRAFT

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Background: The concept of Precision Visual Flight Rules (PVFR) and Simultaneous Non-Interfering (SNI) Routes for rotorcraft is based on the hypothesis that rotorcraft with Global Positioning System (GPS) navigation capabilities can stay within narrow, defined horizontal airspace limits while operating under Visual Flight Rules (VFR). If the pilot maintains the aircraft within the confines of a PVFR route and if these routes can be designed to keep rotorcraft separated from fixed-wing traffic then PVFR routes offer rotorcraft the possibility of operating in congested airspace simultaneously with fixed-wing aircraft on a non-interfering basis, hence the term SNI operation.

INTRODUCTION

Many helicopter operators have a requirement to operate using Visual Flight Rules (VFR) in busy terminal areas in a safe and efficient manner in airspace that does not conflict with fixed-wing traffic. Similarly air traffic service providers have a requirement to keep helicopter and fixed-wing traffic separated for safe and efficient terminal area operations. A concept for meeting both requirements is Precision VFR (PVFR) routes, which allow helicopters to operate within defined airspace limits that assure their separation from fixed-wing traffic.

At present there are no standards or flight test data that address issues of the width of PVFR routes or the ability of pilots to follow GPS routes while performing the necessary tasks to operate their aircraft under VFR. While GPS use during VFR operations is common practice in the NAS, the required use of GPS on PVFR routes to keep an aircraft within defined airspace limits has not been validated.

OBJECTIVES

The objective of the PVFR/SNI project is to evaluate the ability of GPS to provide lateral guidance for helicopters flying on PVFR routes while using barometric altitude for vertical guidance. A secondary objective is to develop and demonstrate PVFR routes and ATC procedures that use GPS to enhance the helicopter pilot's ability to navigate more efficiently in the National Airspace System (NAS). The results of this research and development effort will be used by the Federal Aviation Administration (FAA) to determine

airspace requirements, air traffic control procedures, and pilot operational and training considerations.

The flight test will assess human factors, flight technical error (FTE), navigation system error (NSE), and total system error (TSE) associated with operating GPS-equipped helicopters during PVFR/SNI operations. FAA can use these assessments to develop policy, criteria and guidance to support implementation of PVFR/SNI operations. Specific operations that may be enhanced by PVFR routes include helicopter transitions through control zones and congested airspace and flights through areas with natural or manmade obstacles, such as mountain passes and valleys.

TEST METHODOLOGY

The FAA has determined that the assessment of PVFR human factors and route widths will be performed by a combination of flight test and simulation methods. This paper describes the flight test portion of the PVFR/SNI project. The PVFR simulation effort is described in another paper prepared by the Naval Postgraduate School (NPS).

A key element of the overall test methodology is to provide means to correlate results of the flight testing and the simulation. This allows simulation to support areas that cannot be adequately addressed by flight testing and vice versa. Agreement between the flight-testing and simulation results offers the opportunity to significantly expand the supporting data.

ROLES AND RESPONSIBILITIES

The flight-test evaluation is the responsibility of Satellite Technology Implementation, LLC (STI) of Orange Beach, AL. STI, under contract to the FAA, is supported by the University of Tennessee Space Institute (UTSI) to provide a test helicopter, maintenance support, safety pilot, and technical assistance.

Overall test coordination and technical direction for the PVFR project is provided by FAA Human Factors Division (AAR-100) located at FAA Headquarters in Washington, DC and FAA General Aviation and Vertical Flight Office (AAR-460) located at the William J. Hughes Technical Center, Atlantic City, NJ. AAR-100 and AAR-460 are supported by the FAA's Flight Technologies and Procedures Division (AFS-400), the sponsoring organization for the project.

TEST PLAN

The conduct of the flight test is governed by the PVFR/SNI Flight Test Plan. The test plan describes all of the elements that comprise the complete test program.

Test Aircraft. STI has selected an Army OH-58A helicopter operated by UTSI to be the test aircraft. A large percentage of helicopter pilots have flown the OH58, its civil variant (the Bell 206 Jet Ranger), or the Navy variant (the TH-57 basic flight trainer). Use of this helicopter addresses a number of test considerations. The test aircraft:

- Is representative of VFR helicopters in widespread use in the NAS,
- Is familiar to most subject pilots,
- Is large enough to carry all necessary test personnel and equipment, and
- Permits the simulation phase of the assessment to model a single helicopter.

The test aircraft is equipped with a Bendix-King Model KLN89B GPS receiver. This is a panel-mounted receiver certified to the standards of FAA's Technical Standard Order (TSO) C129 Class A1.

Subject Pilots. Testing will be completed using 10 subject pilots. Pilots will be a mix of VFR- and IFR-rated pilots with a target of 5 VFR and

5 IFR rated pilots. This mix of pilots is representative of the population of licensed helicopter pilots 'at large'. Some subject pilots will be selected from Navy instructor pilots who will be available to participate in the simulation tests at NPS.

To correlate flight test and simulation results, each subject pilot will wear a head-mounted head and eye tracker during some or all of the test flights. A description of the head and eye tracking system is provided in a separate paper by NASA Ames Research Center.

PVFR Test Route. The flight tests will be performed in the airspace around Tullahoma, TN Regional Airport (THA).

STI designed a route specifically for the PVFR flight testing. This route is representative of VFR routes in use in the NAS and represents a broad range of operational and support conditions, to include:

- Terrain and obstacles are consistent with those found in a VFR route environment,
- Aircraft and test personnel can be supported logistically,
- Test area is suitable for day and night VFR operations,
- Test route represents a realistic ATC environment,
- Route segments and turn angles are representative of a typical VFR route, and
- VFR waypoints¹ are identifiable by terrain or manmade features during day and night operations; waypoints will be connected by straight segments so routes can be defined by overlaying GPS waypoints on the VFR waypoints.

A map of the test area including the PVFR route is shown in Figure 1. The Tullahoma area allows testing of the PVFR/SNI concept in a feature-rich region. Features found along the test route include highways, cell and water

¹ A VFR waypoint is defined as a natural or manmade feature, recognizable to the pilot, which marks the intended path of the aircraft.

A GPS waypoint is defined by latitude and longitude coordinates that can be entered manually or automatically in a GPS receiver.

towers, power lines, bridges, a river, a lake, a dam, a factory complex, and a power plant.

The route is designed to test pilot performance in straight segments and turns. Straight segments range from 1 to 6 NM in length. Numerous turns (20 in all) ranging from 6 to 125 degrees are provided in the PVFR route. For analysis, the turns are divided into 4 conditions. These conditions and the number of conditions per flight are shown in Table 1.

Table 1 Test Conditions - Turn Events per Flight		
Condition/Event	Turn Angle (Degrees)	No. of Turns
1	0-29	6
2	30-59	5
3	60-95	5
4	>95	4

The route segments and waypoints are designed to evaluate several test conditions. Some route segments follow well-defined visual features; some route segments are near (but do not overlie) visual features; and some route segments do not follow any defined visual features. These test conditions will provide indications as to whether subject pilots are relying primarily on GPS or visual navigation cues.

TEST MATRIX

Based on test requirements, STI has constructed a test matrix that supports the objectives of the PVFR/SNI project. This test matrix was used to guide the development of the actual test plan routes.

A total of 14 data collection flights will be flown; 10 flights will be flown during daylight hours; 4 flights will be flown during nighttime hours. Data collection will be performed on all flights. Flights will:

- Originate and terminate at THA with a transition to the PVFR route,
- Be flown during VMC using VFR,
- Be hand flown (no autopilot flights),
- Be flown within the standard cruise speed range for the OH-58A and a speed that is

comfortable to the subject pilot (typically 70 to 90 knots), and

- Be conducted using standard rate turns.

Adherence to the test matrix will provide a sufficient number of data sets to assure statistical significance for straight and turning flight.

The test matrix, which relates subject pilots, test conditions, and flights, is shown in Table 2. It provides a familiarization flight to allow each pilot some time to operate the aircraft and systems for approximately 30 minutes prior to the beginning of data collection. Following the familiarization flight the data collection flight will begin.

DATA REQUIREMENTS

Subject Pilot Data. Each subject pilot will complete a pre-test questionnaire and post-flight questionnaires at the conclusion of each flight.

The pre-test questionnaire will provide background information on experience level, currency, aircraft flown, etc. To maintain the privacy of the subject pilots, data on individual pilots will be known only to STI test personnel and will not be released or otherwise made available to the FAA. Pilot data provided to the FAA will be in summary format.

Each subject pilot will complete a post-flight questionnaire to collect the pilot's assessment of the operation of the aircraft and the GPS receiver during the flight. Questions will be of two forms: 1) quantitative ratings to assess the level of difficulty or risk associated with flying or operating the GPS equipment during the flight, and 2) questions soliciting pilot comments on positive and negative aspects of operating aircraft and GPS equipment on PVFR routes. Pilots will be asked to identify specific visual references they used during the flight. This information will be provided to NPS for use in the simulator tests.

True Aircraft Position Digital Data. The true position of the aircraft will be determined by a Time and Space Position System (TSPI). The TSPI consists of a survey quality GPS tracking system. TSPI data is processed post flight to produce highly accurate aircraft true position (less than 1 meter error).

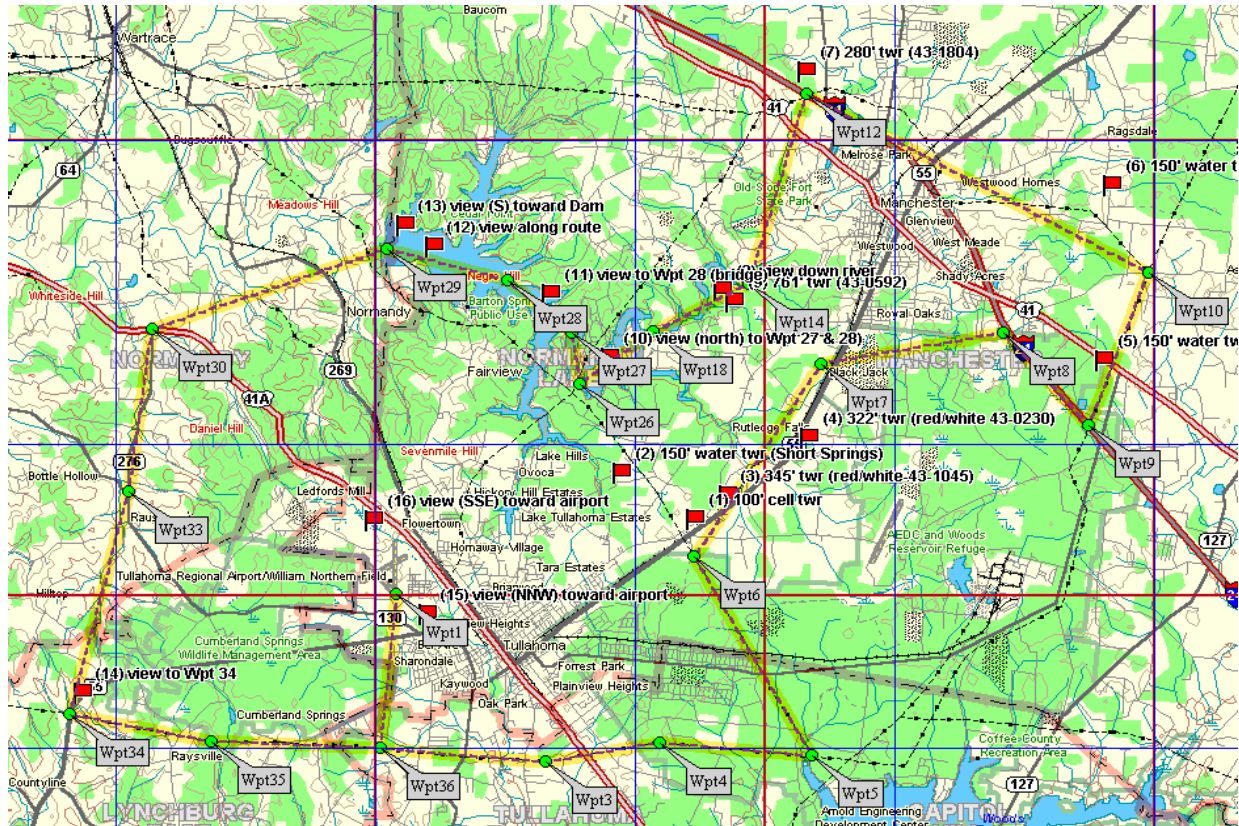


Figure 1 PVFR Test Route (Final Draft)

Table 2 PVFR Flight Test Matrix

Pilot	Rating	Event 1	Event 2	Event 3	Event 4	Total
1	IFR/VFR	6	5	5	4	20
2	VFR-Only	6	5	5	4	20
3	IFR/VFR	6	5	5	4	20
4	VFR-Only	6	5	5	4	20
5	IFR/VFR	6	5	5	4	20
6	VFR-Only	6	5	5	4	20
7	IFR/VFR	6	5	5	4	20
8	VFR-Only	6	5	5	4	20
9	IFR/VFR	6	5	5	4	20
10	VFR-Only	6	5	5	4	20
1	IFR/VFR	6	5	5	4	20
2	VFR-Only	6	5	5	4	20
3	IFR/VFR	6	5	5	4	20
4	VFR-Only	6	5	5	4	20
Data sets	(minimum)	60	50	50	40	200
Data sets	(optional)	24	20	20	16	80
Data sets	(total)	84	70	70	56	280

10 day flights –
number and makeup
of subject pilots:
(1) 50% IFR/VFR
(2) 50% VFR-Only
(3) Operational
pilots from private,
industry, and military
(Navy).

4 night flights –
number and makeup
of subject pilots:
(1) Two IFR/VFR
pilots from military
(Navy)
(2) Two VFR-Only
pilots from private
industry.

Note: Pilots 1 through 4 fly one night flight and one day flight. Pilots 5 through 10 fly one day flight.

Airborne Digital Data. Digital data from the aircraft's GPS receiver and altimeter system will be recorded during all test flights by a personal computer (PC)-based data collection and recording system. Data will be recorded at the highest rate available from the receiver. Typically, these data are available at a 1-Hertz (Hz) rate.

Concurrent with the recording of the TSPI and airborne systems data, personnel from NASA Ames will be collecting data on the pilots' head and eye position during the test flights. STI personnel will coordinate with NASA Ames personnel to assure that digital data from the airborne GPS system, the TPSI, and the head and eye tracker are time-correlated. This will allow an assessment of FTE error growth during times that the pilot's attention is focused on tasks outside the cockpit.

Flight Log. The onboard flight test engineer will maintain a flight log. The engineer will record details of the flight including: subject pilot number; test run number; start and end flight time; pilot verbal comments; reported temperature and winds; and any other information considered pertinent by the flight test engineer.

Data Reduction. Data from the PC-based onboard digital data recording system will be time-merged with TPSI data. Data processing software, developed by STI, will produce time series of cross track error. The components of cross track error will be broken down into Navigation System Error (NSE), Flight Technical Error (FTE) and Total System Error (TSE).

TEST EXECUTION

Pre-Test Briefing. Subject pilots will be given a local area orientation and a pre-test briefing describing the purpose of the test, the test route, and the test conditions. The subject pilot will also be asked to complete the Pre-Test Questionnaire at this time.

Familiarization Flight. To establish a baseline experience level for all subject pilots, each pilot

will fly a familiarization flight with as many flight segments as needed to become familiar with the test routes and aircraft systems. The familiarization flight route will be different than the PVFR test route used for data collection.

Data Collection Flights. After completing the familiarization flight, the subject pilot will fly one or two data collection flights as dictated by the test matrix. Data collection flights will consist of a VFR departure from THA. The flight then will then transition to a PVFR route for the en route segment. The flight will conclude with a VFR transition from the PVFR route to THA.

Post-Test Debriefing. The subject pilot, safety pilot, and flight test engineer will review events and subject pilot comments from the flight log. They will also discuss general comments on the PVFR test program. In particular, the subject pilot will be asked to discuss areas of concern or uncertainty regarding operational use of PVFR routes. To protect the privacy of the subject pilots, these comments will be treated with confidence by the interview team and will not be attributed to specific pilots. Only summary comments will be provided to the FAA and the identity of the subject pilot making such comments will not be released to the FAA.

SCHEDULE

Key schedule milestones are shown below:

- Test Plan Complete: 06-30-03
- Test Readiness Demonstration: 09-30-03
- Data Collection Complete: 10-31-03
- Draft Test Report Complete: 08-31-04
- Final Test Report Complete: 12-31-04

SUPPORTING DOCUMENTATION

Documents and technical direction related to this test include:

1. FAA Aeronautical Information Manual (AIM).
2. FAA Order 7110.65N; Air Traffic Control